

AMENDMENTS TO THE CLAIMS

1. (Previously Presented) A hardware apparatus for analyzing a sound signal, comprising:

an ear model for deriving, for a number of inner hair cells, an estimate for a time-varying concentration of a transmitter substance inside a cleft between an inner hair cell and an associated auditory nerve from the sound signal, so that an estimated inner hair cell cleft contents map over frequency and over time is obtained, wherein the inner hair cells comprising lower order inner hair cells indicating lower frequencies and higher order inner hair cells indicating higher frequencies; and

a pitch analyzer for analyzing the cleft contents map to obtain a pitch line over time, the pitch line indicating a pitch of the sound signal for respective time instants, wherein the pitch line varies in time over higher frequencies and lower frequencies as determined by the pitch analyzer.

2. (Previously Presented) The hardware apparatus in accordance with claim 1, further comprising a rhythm analyzer for analyzing estimates for selected inner hair cells, the inner hair cells being selected in accordance with the pitch line, so that segmentation instants are obtained, wherein a segmentation instant indicates an end of a preceding note or a start of a succeeding note.

3. (Previously Presented) The hardware apparatus in accordance with claim 1, in which the ear model comprises:

a mechanical ear model for modeling an auditory mechanical sound processing up to the inner ear (cochlea) to obtain estimates for representations of mechanical vibrations of the basilar membrane and lymphatic fluids; and

an inner hair cell model for transforming the estimates for representations of mechanical vibrations into the estimates for the transmitter concentrations at the inner hair cells.

4. (Previously Presented) The hardware apparatus in accordance with claim 1, in which the ear model is operative to calculate a transmitter concentration for at least 100 inner hair cells,

wherein each inner hair cell is associated with a specified area of a modeled basilar membrane, and wherein each inner hair cell has associated therewith a different specified area of the modeled basilar membrane.

5. (Previously Presented) The hardware apparatus in accordance with claim 1,

wherein the pitch analyzer further comprises a vibration period detector, the vibration period detector being operative for calculating a summary auto correlation function for each time period of a number of adjacent time periods using the estimates for the transmitter concentrations of the number of inner hair cells, and

wherein the vibration period detector is further operative, for each inner hair cell, to calculate at least one period between two adjacent maxima in one estimate, and to enter a result into a summary auto correlation function histogram.

6. (Previously Presented) The hardware apparatus in accordance with claim 5, in which the pitch analyzer is operative to retrieve a maximum value from each histogram of the time sequence of histograms, the maximum value representing a pitch in the time period so that pitch line points are obtained.

7. (Previously Presented) The hardware apparatus in accordance with claim 6, in which the pitch analyzer is further operative to build pitch line subtrajectories by combining pitch line points being close in time with respect to a time threshold and being close in frequency with respect to a frequency threshold.

8. (Previously Presented) The hardware apparatus in accordance with claim 7, in which the pitch line analyzer is further operative to fuse pitch line subtrajectories with a minimum length and to discard any subtrajectories not fulfilling a criterion related to a minimum length and amplitude.

9. (Previously Presented) The hardware apparatus in accordance with claim 2, in which the rhythm analyzer comprises a searcher for searching a dominant estimate for a transmitter concentration in a specified time period and comprising a dominant frequency determined by the pitch line so that, for adjacent time periods, corresponding dominant estimates for different inner hair cells are obtained, wherein the searcher is operative to acknowledge a dominant estimate, when the dominant estimate is above a threshold.
10. (Previously Presented) The hardware apparatus in accordance with claim 9, in which the threshold is an amplitude of an estimate comprising the second largest amplitude so that the dominant estimate comprises the largest amplitude in a specified time period.
11. (Previously Presented) The hardware apparatus in accordance with claim 2, in which the rhythm analyzer is operative to build an onset map by calculating an onset value for a dominant estimate for a specified time period, the onset map including a sequence of onset values.
12. (Previously Presented) The hardware apparatus in accordance with claim 11, in which the rhythm analyzer is operative to calculate an onset value such that an onset value is higher, when an onset comprises a stronger onset rise, compared to another onset comprising a weaker onset rise.
13. (Previously Presented) The hardware apparatus in accordance with claim 11, in which the rhythm analyzer is operative to calculate an onset value such that the onset value is higher, when a starting level before an onset is lower compared to another onset comprising a higher starting level.
14. (Previously Presented) The hardware apparatus in accordance with claim 2, in which the rhythm analyzer is operative to use an estimate for an inner hair cell representing a fundamental vibration or using an estimate for an inner hair cell representing at least one higher partial vibration.
15. (Previously Presented) The hardware apparatus in accordance with claim 2, in which the rhythm analyzer is operative to build an onset histogram by combining onset values of estimates for an inner hair cell representing the fundamental

vibration, and onset values of an estimate for an inner hair cell representing at least one higher partial vibration, which comprises a time distance smaller than a specified time distance threshold.

16. (Previously Presented) The hardware apparatus in accordance with claim 11, in which the rhythm analyzer is operative to extract maxima from the onset histogram, wherein a time value associated with a maximum indicates a segmentation instant.
17. (Previously Presented) The hardware apparatus in accordance with claim 1, further comprising a timbre recognition module, the timbre recognition module being operative for:
 - constructing a feature vector;
 - feeding the feature vector into a pattern recognition device; and
 - obtaining a result indicating a probability that at least a portion of the sound signal has been produced by a sound source from a number of different specified sound sources.
18. (Previously Presented) The hardware apparatus in accordance with claim 17, in which the pattern recognition device is a neural network.
19. (Previously Presented) The hardware apparatus in accordance with claim 17, in which the feature vector comprises one or more selected members from a feature group including onset time of a fundamental vibration or a higher order partial vibration, a frequency of a fundamental vibration or a higher order partial vibration, an amplitude of a fundamental vibration or a higher order partial vibration, a number of an estimate for the transmitter concentration using the highest peak for the fundamental vibration or a higher order partial vibration, or a number of an estimate for the transmitter concentration being in resonance for a fundamental vibration or a higher order partial vibration.
20. (Previously Presented) The hardware apparatus in accordance with claim 2, further comprising a transcription module, the transcription module being

operative for using the pitch line segmented at segmentation instants to output a note description or a MIDI description.

21. (Previously Presented) A method of analyzing a sound signal, comprising:

deriving, for a number of inner hair cells, an estimate for a time-varying concentration of a transmitter substance inside a cleft between an inner hair cell and an associated auditory nerve from the sound signal, so that an estimated inner hair cell cleft contents map over frequency and over time is obtained, wherein the inner hair cells comprising lower order inner hair cells indicating lower frequencies and higher order inner hair cells indicating higher frequencies; and

analyzing the cleft contents map to obtain a pitch line over time, a pitch line indicating a pitch of the sound signal for respective time instants, wherein the pitch line varies in time over higher frequencies and lower frequencies as determined by analyzing the cleft contents map,

wherein the method of analyzing is implemented in hardware in the form of a state machine or in software, which is executed by a programmable processor for performing the method of analyzing.

22. (Withdrawn) Computer program having instructions being operative for performing a method of analyzing a sound signal when the program runs on a computer, the method of analyzing a sound signal comprising the following steps:

deriving, for a number of inner hair cells, an estimate for a time-varying concentration of a transmitter substance inside a cleft between an inner hair cell and an associated auditory nerve from the sound signal, so that an estimated inner hair cell cleft contents map over time is obtained; and

analyzing the cleft contents map to obtain a pitch line over time, a pitch line indicating a pitch of the sound signal for respective time instants.

23. (Previously Presented) The hardware apparatus of claim 1,

wherein the pitch line over time is used for one or more members of the group comprising: performing a transcription, performing a sound source recognition, performing a music recognition, performing a query by humming process, displaying the pitch line over time, extracting auditory streams, identifying performing singers, and performing an instrument recognition.

24. (Previously Presented) The method of claim 21,

wherein the pitch line over time is used for one or more members of the group comprising: performing a transcription, performing a sound source recognition, performing a music recognition, performing a query by humming process, displaying the pitch line over time, extracting auditory streams, identifying performing singers, and performing an instrument recognition.